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The Research on Factors Influencing Air Pollution

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Abstract:

The rapid development of urbanization contributes to that the people' life is more and more beautiful and their quality of life is better and better. There are a lot of complex and diversity influencing of air pollutants. This paper finds a lot of articles and reports of government and focus on four air pollutants: carbon monoxide, ozone, nitrogen oxides, and particulate matter, including ultra-fine particles. Air pollution can cause three major environmental problems, including greenhouse effect, acid rain, and ozone hole, which can cause significant damage to the lungs and respiratory tract of the human body, such as chronic lung disease, neurological damage, and heart disease. The purpose of the article is to find some factors that affect air pollution. Using the method of multiple linear regression turns out that there is a significant linear regression relationship between human activities, exhaust emissions from vehicles, ships, airplanes, industrial pollutant, meteorological conditions, landform and PM2.5, while the speed and direction of wind fail the important test.

Keywords: Air pollution; multiple linear regression; relationship.

1. Introduction

China has recently seen extreme air pollution with elevated levels of PM2.5 and ozone (O3) due to the country's fast-growing industrialization, urbanization, and transportation sectors. China's economy is now in a stage of high-quality development as opposed to one of rapid expansion. As a result, China is going through a process of changing its development mode through economic structure optimization and growth momentum shifting. Reducing environmental strain, enhancing air quality, and increasing resource and energy use efficiency are all urgently needed [1]. China's energy use is currently under effective control. Limiting the amount of coal used overall, promoting clean fossil fuel use, and rapidly increasing non-fossil energy have all improved energy use. According to research, in 2017 non-fossil energy consumption accounted for 13.8% of primary energy consumption, with a 60% goal completion rate. The combined effects of effective energy control and structure of energy optimization resulted in a reduction of 5.6%, 6.4%, 13.2%, and 8.7% in the overall emissions of nitrogen oxides, sulfur dioxide, and total ammonia nitrogen in 2017.China's strong implementation of several low-carbon and air pollution control programs in recent years has played a significant role in the achievement of these results [2]. Environmental pollution is a serious issue that causes a health risk, and thus air pollution should be addressed.

First, research on influencing factors has shown that, in addition to pollution sources, natural and human factors, including terrain, wind speed, and ecological space, as well as the distribution of built environment factors like industrialization, energy consumption, and social economy, are all significant factors that interact to affect the state of air pollution. Since necessary variables for planning and construction are not sufficiently taken into account, more research is currently required to understand the mechanisms and influencing factors of urban air pollution. Additionally, further study is needed to understand the mechanisms of interaction among these components [3, 4].

Furthermore, multiple line regression is a more dependable and informative research methodology than traditional methods. It may assess the interaction between many factors, uncover detailed correlations between various components, and quantitatively assess the explanatory power of specific variables and two factor interactions. Multiple line regression is a useful technique for identifying and attributing spatial stratified heterogeneity because of all these characteristics [5].

Shijiazhuang City, a significant city in the Beijing-Tianjin-Hebei (BTH) area of China, has fast economic growth along with mounting environmental strain and significant air pollution issues. Regarding the level of industry and urbanization, as well as the intensity of air pollution, Shijiazhuang City is typical and indicative of the BTH region. Additionally, the BTH region, which includes Shijiazhuang, is a key Chinese core region and the subject of air pollution study [6-8]. Regional sustainable development is still severely limited by air pollution prevention and management, despite the results of countless previous studies, and technological barriers still need to be removed. The Air Pollution Index (API) reflects the short-term air quality status and changing trends of a city [9-11]. Therefore, the main influencing factors of air pollution have been identified using multiple regression lines, and scientific support has been provided for ai quality in typical polluted cities like Shijiazhuang.

2. Methods

2.1 Data Source

The data is sourced from the daily air quality reports of Shijiazhuang and Qinhuangdao. According to the data center of the Ministry of Environmental Protection, the data includes daily air pollution index, primary pollutants, air quality levels, and air quality status. The China Meteorological Science Data Sharing Service provides a series of Meteorological data, having various networks, including air pressure, wind speed, temperature, and relative humidity. The research period was from January 2009 to December 2012.

2.2 Variable Selection

Air pollution is the result of the changes in international technological development, reflecting the overall trend of global environmental quality and being influenced by industrial processes and carbon dioxide, sulfur dioxide, PM2.5 and some other factors. These factors are irregular and unpredictable, therefore, changes in factors can be very frequent, and difficult to determine the magnitude of the changes, as illustrated in Figure 1:

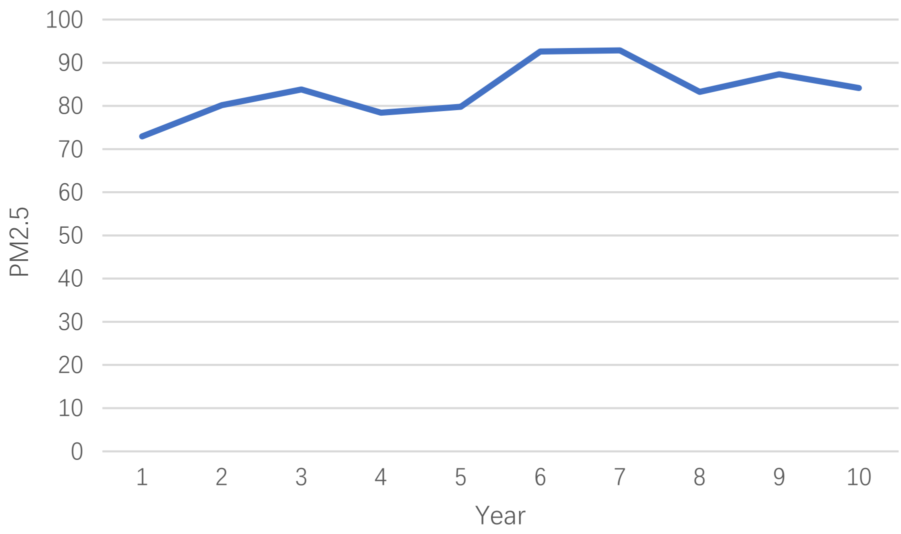

Fig. 1 The annual PM2.5 values from 2001 to 2010 in Shijiazhuang

The International Organization for Standardization (ISO) defines air pollution as: resulting from either natural or human-caused factors. As a result of the process, some compounds enter the atmosphere, collect for a sufficient amount of time, and become dangerous for the environment, human comfort, or welfare. From another perspective, we might refer to a chemical as an air pollutant when its presence results in a phenomena known as air pollution. The substance must exist in sufficient quantity, characteristics, and duration to affect humans, other species, or property. In the end, it was determined that the primary elements influencing air pollution were the quantity of cars, industry, and wood usage.

2.3 Method Introduction

The effects of several influences on the air are compared in the paper using a multiple linear regression model. A linear regression model containing several explanatory variables is called a multiple linear regression model. It serves as an explanation for the linear relationship that exists between the variable being explained and several additional explanatory factors. The multiple linear regression model's underlying idea is the least squares method, which computes parameter values by reducing the sum of squared residuals. The discrepancy between a model's true value and its anticipated value is referred to as residual. Finding a set of parameters that minimizes the sum of squared residuals for every data point is the aim of the least squares technique. By solving the least squares estimation, the model's Parameter estimation value.

3. Results and Discussion

3.1 Linear Regression Model

The analysis in this paper illustrates that there are many factors of influencing air quality. As the Figure 2 show:

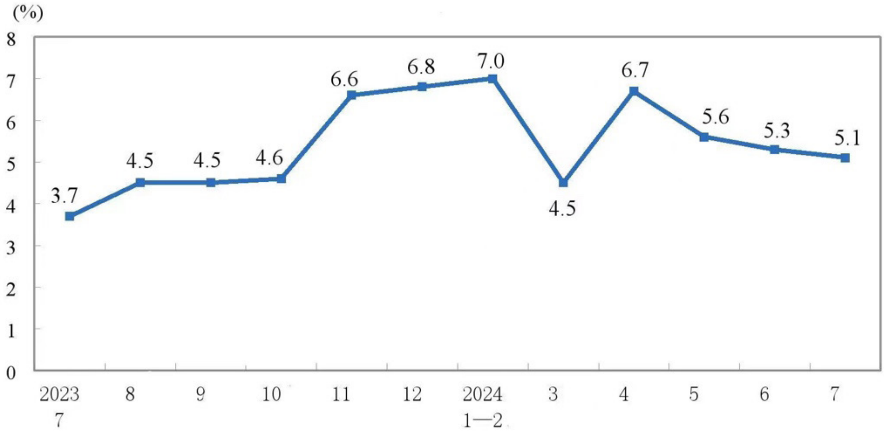

Fig. 2 The year-on-year growth rate of added value of industrial enterprises above designated size from July 2023 to July 2024.

Figure 2 shows that in actual terms, in July 2024, the added value of industrial businesses larger than the authorized size increased by 3% annually. On the other hand, in March 2024, there was a 0.08% decline in the added value of industrial firms that were larger than the designated size. The additional value of industrial firms larger than the required size rose by 6.1% annually between January and March of 2024. This suggests that there has always been a growth trend in China's business.

In the Beijing Tianjin Hebei (BTH) region and the area in question, the average concentration of PM2.5 in "2+36" cities was 27 micrograms per cubic meter in June, representing a 22.7% year-over-year rise; the average concentration of O3 was 221 micrograms per cubic meter, representing a 0.9% year-over-year drop. The percentage of average good days was 19.6%, indicating a decrease of 18.0%; the percentage of average severe and above pollution days was 0.3%, indicating a decrease of 0.5 percentage points from year to year; and the percentage of average days exceeding the standard due to sandstorms was 1.4%.

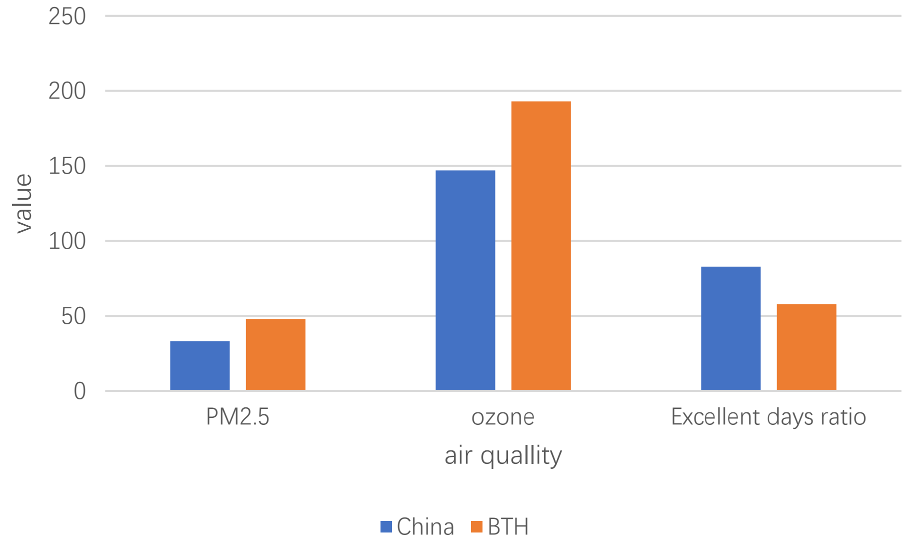

Fig. 3 Air quality in 2024

The average concentration of PM2.5 in "2+36" cities in the Beijing, Tianjin, Hebei region and its environs from January to June was 48 micrograms per cubic meter, up 2.1% from the previous year; the average concentration of O3 was 193 micrograms per cubic meter, up 9.7% 16 6 30 from the previous year (Figure 3). The percentage of good days on average was 57.7%, which is a 1.36% decline from the previous year due to sandstorms. Beijing's PM2.5 concentration was 26 micrograms per cubic meter in June, which is equivalent to 7 percentage points; 3.0% of days had average severe pollution, which is the number of days per year that exceed the norm and result in an increase of 2.8 percentage points on year 33.4; The meter saw a 30.0% growth in the previous year; At 230 micrograms per cubic meter, the O3 concentration had decreased 8.4% from the previous year. There were no days of severe or above pollution, a loss of 3.3 percentage points from the previous year; the percentage of days surpassing the standard due to sandstorms is 6.7%. The proportion of good days was 23.3%, a decrease of 33.4 percentage points from the previous year. Beijing's PM2.5 concentration decreased by 8.1% year over year to 34 micrograms per cubic meter from January to June, while the O3 concentration increased by 11.4% year over year to 195 micrograms per cubic meter. The percentage of good days was 70.9%, up 1.3 percentage points from the previous year; the percentage of days with severe or higher pollution was 0.5%, down 3.9 percentage points from the previous year. The percentage of days. The proportion of days exceeding the standard caused by sandstorms is 3.8%.

Table 1. The values of forest coverage, car sales, PM2.5 and industrial enterprise data between 2001 to 2010

Year	forest coverage	Car sales	PM2.5	Industrial enterprise
2001	17.69	237	72.94729	171259
2002	17.69	325	80.17655	181560
2003	17.69	439	83.80247	196225
2004	22.3	507	78.43698	279097
2005	22.3	576	79.80029	270048
2006	22.3	722	92.62106	301967
2007	22.3	879	92.85222	336774
2008	22.3	938	83.25883	412220
2009	23.4	1364	87.32314	366137
2010	25.6	1806	84.15741	414822

Table 1 illustrates that the air quality in China has decreased with the development of industry. The forest coverage remained unchanged from 2001 to 2003, which always maintained at 17.69; this figure 3 experienced a rapid increase in 2004, which reached 22.3, but remained unchanged until 2008. There was a sharply grew in forest coverage from 22.3 in 2008 to 25.6 in 2010.

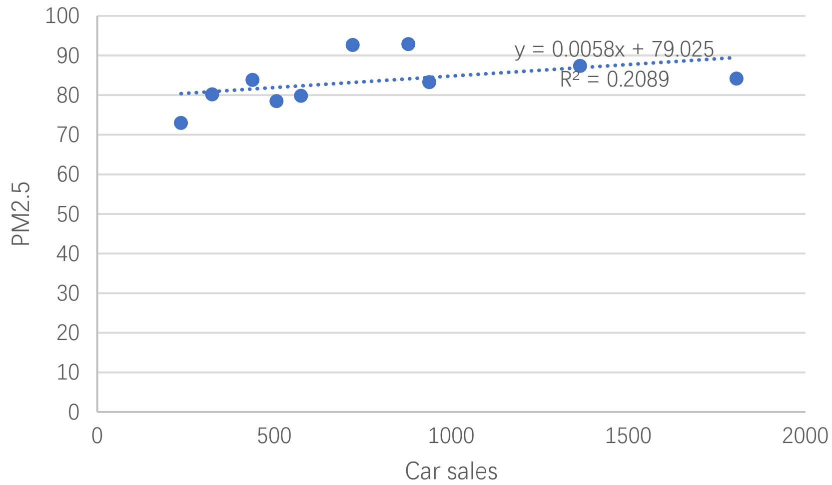

Fig. 3 Regression Line of Car Sales against PM2.5

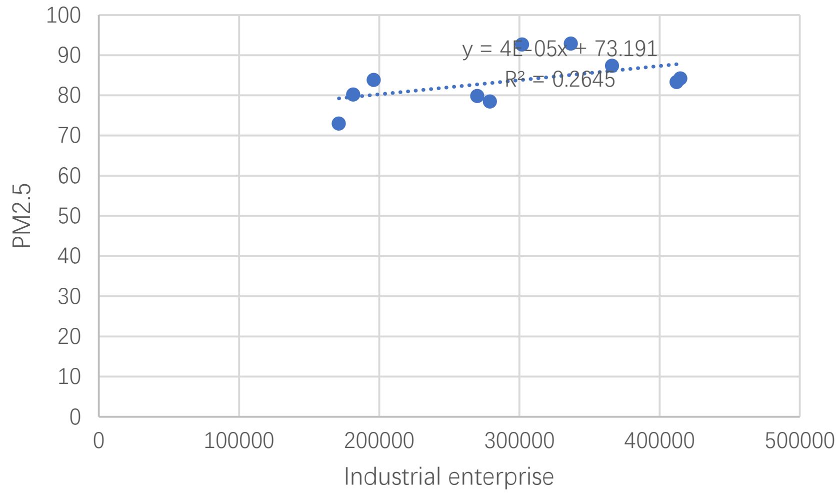

Fig. 4 Regression Line of Industrial Enterprise Data against PM2.5

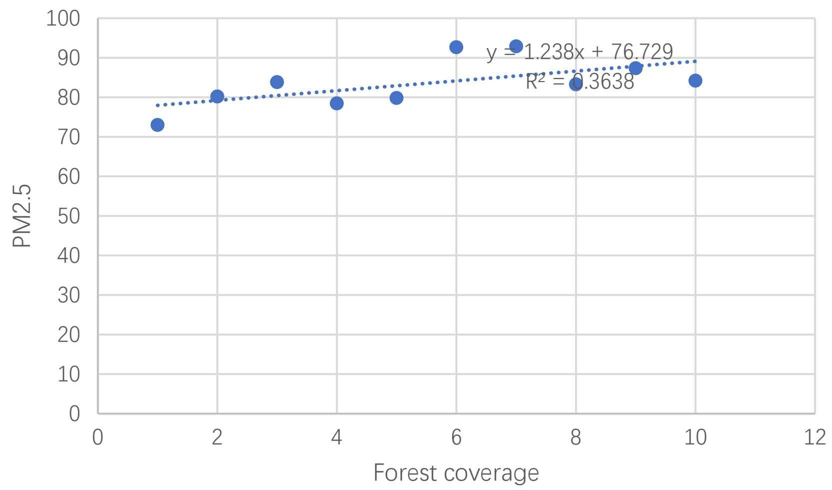

Fig. 5 Regression Line of Forest Coverage against PM2.5

According to Figure 1, regression lines were created for different factors (Figure 3, 4 and 5), with forest cover having the largest square of R, reaching 0.3638. The square of R for industrial data was approximately 0.1 smaller than it. The square of R for car sales was the smallest, which reach 0.2089.

3.2 Multiple Regression Linear

According to table 2, the VIF of these factors all smaller than 10, which illustrate that the collinearity problem is not serious. Using R-square analyzes the goodness of fit of a model, also known as the coefficient of determination. R. The value of the square ranges from 0 to 1, representing the degree of fit of the model. The square of R is 0.266, indicating that these factors can illustrate the 26.6% change in PM2.5 content. The coefficient of forest coverage is negative, which means that PM2.5 decreases as the forest coverage increases. The coefficient of Industrial enterprise data and car sales are negative, which mean that PM2.5 increase as the Industrial enterprise data and car sales increase. The factor that affects PM2.5 among these three factors is Industrial enterprise data.

Table 2. Model results

		S.E.	Coefficient	t	p	VIF	Tolerante
Constant	75.649	28.866	-	2.621	0.040*	-	-
Forest Coverage	-0.154	1.923	-0.067	-0.08	0.939	5.818	0.172

Industrial Enterprise	0	0	0.529	0.576	0.586	6.906	0.145
Car Sales	0.001	0.009	0.052	0.07	0.946	4.55	0.22
Square of R	0.266						
Adjust the Square of R	-0.102						
F	F (3,6) =0.723, p=0.574						
D-W	1.807						

4. Conclusion

Through the research in this article, it can be concluded that if carbon dioxide emissions do not increase significantly, the overall trend of change next year will decrease. However, due to the uncertainty of international industrial development and changes in forest coverage, further predictions will become even more inaccurate. At the same time, in recent years, the world has been affected by the pandemic, and the economies of various countries have been affected and are in a period of recovery, which will make air quality more difficult to predict.

Among car sales, forest coverage, and industrialization, industrialization has the most serious impact on air pollution. However, there are still some shortcomings, such as the fact that this study has not studied many factors that affect air quality, such as household waste gas and the use of nonrenewable energy. In addition, there are some uncontrollable factors that may lead to errors in this article, such as human activities, climate change, geographical environment, and so on. With the popularization of electric vehicles and the increase in forest coverage, the pollution caused by car exhaust to the environment has been greatly reduced.

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